The Electromagnetic Cause of Shell Shock
Frank H. Makinson IEEE Member

Abstract—The pathology of shell shock, contemporaneously grouped with post-traumatic stress disorder, has been identified by researchers. Why the brain injury occurs primarily in the frontal lobes and its “distinctive honeycomb pattern of broken and swollen nerve fibres” was not identified. Every munitions explosion emits a broadband pulse of electromagnetic energy. The electromagnetic energy pulse reaches the victim before the compression and particle components of the explosion. The characteristics of the head protection used by soldiers explains why the particular shell shock brain injury has an inordinate prevalence today, but without the massive artillery barrages. The victims are receiving what can be termed an electric shock frontal lobotomy.

I. Introduction

A recent newspaper article was titled, “The mystery of shellshock solved: Scientists identify the unique brain injury caused by war.”[1] The description of the brain injury is provided in one paragraph, “Described as a ‘distinctive honeycomb pattern of broken and swollen nerve fibres’, the injuries were not the same as those found in car crash and drug overdose victims, or sufferers of punch-drunk syndrome, which is caused by repeated blows to the head.” The one researcher specifically cited in the report is Professor Vassilis Koliatsos of John Hopkins University.[2] Basically, the researchers identified the pathological characteristics of the brain damage, but they did not identify the specific mechanism that caused the unique damage.

In World War I (WWI), the massive artillery barrages exposed soldiers to nearby munitions explosions and many of those that survived the blast damage, with no obvious cranial injuries, afterward displayed erratic emotional behavior. The term shell shock was coined to describe the outward characteristics. The current term used to describe those that display the effects of nearby munitions explosions is grouped with post-traumatic stress disorder (PTSD), which covers traumatic events that do not involve the victim having been in close proximity to a nearby munitions explosion.

One might expect that World War II and the Korean War, where U.S. soldiers were exposed to nearby munition explosions, would have produced the same scale of shell shock as WWI, but the percentage of shell shock victims appeared to be much lower as the condition was not mentioned prominently in the press. There is a common thread associated with the incidence of shell shock and the type of cranial protection issued to U.S. and British soldiers in the different wars.

In WWI, the steel Brodie helmet was standard for British troops and the similar design steel M-1917 was issued to U.S. troops. These helmets covered the top cranial area and the flared rim did not extend below the top of the ear lobe and much of the forehead was exposed. The steel U.S. M1 helmet was adopted in 1941, and it covered a larger percentage of the cranial area in the front, and the sides extended downward about halfway over the ear lobe. The non-steel Kevlar helmet (K-pot) was adopted by the U.S. in the mid-1980s. The K-pot has superior ballistic performance over steel and its size protects a greater percentage of the cranial area from ballistic injuries.

It is not commonly recognized that a munition explosion produces a broadband high intensity electromagnetic pulse (EMP), even though the observed bright flash of an explosion is electromagnetic (EM) energy in the optical spectrum range. A high intensity broadband EMP will not readily penetrate steel, but the K-pot will provide little protection from such a pulse.

II. Electromagnetic Spectrum and Human Exposure

The EM spectrum covers frequencies from very low to very high frequencies that extend well above the optical spectral range. Our human sensory systems can directly detect the presence of EM radiation in the optical range and the invisible infrared and ultraviolet frequencies when they produce secondary effects, such surface heating and sunburn. The effects of long term cranial exposure to various levels of EM emissions are being studied, but none of the studies involve very high magnitude EM sources, as it is already known these can cause severe internal body damage.

The visible and heat frequencies of the spectrum of a nearby munitions explosion are readily detected, but the proliferation of other frequencies, with their additive and subtractive components can produce frequencies with wavelengths that can efficiently interact with the neural fibers of the brain as well as other conducting parts of the
human body. The acronym EMF refers to electric and magnetic fields, and is used in the guidelines that limit human exposure to these fields, the specific absorption rate (SAR) regulations.[3] Electrical engineers commonly use the abbreviation EM to mean the same thing as EMF. The EMF exposure guidelines are not keeping up with the rapid development of consumer devices that produce higher and higher frequencies.

EM energy can come in non-ionizing and ionizing form. The ionizing form is that produced from radioactive sources and high intensity EM discharges. It is now known that high altitude electrical discharges can produce both gamma and x-rays.[4] If the magnitude of an EM pulse is high enough, even though it is does not have the high frequency of an ionizing emission, it will produce major damage in a human body.

Frequency and wavelength are inversely proportional. A large wavelength has a lower (smaller) frequency, and inversely, a very small wavelength has a very high (larger) frequency. For EM waves the speed of light is the constant of proportionality between wavelength and frequency. Algebraically, the relationship is expressed as 

$$c = \lambda f$$

where $c$ represents the speed of light, $\lambda$ the wavelength and $f$ the frequency.

EM waves are produced by the motion of electric charges. In a wire, valence electrons near the surface, also called free electrons, are induced to break their molecular bonds by applying a voltage potential across the conductor; the higher the voltage the more electrons are influenced to move. A Los Alamos National Laboratory (LANL) report stated that millions of volts are created within a munitions explosion.[5] The detonation process produces a large volume of free electrons and ions, all of which have a charge, that will be induced to move by the high voltage. The EM dynamics of an explosion are not well documented and it cannot be assumed that the polarization characteristics of EM waves produced by the combination of electrons and ions will be the same as those produced by conventional EM radiating structures; their characteristics will have to be determined by measurement. However, it is expected that the polarization of the resulting EM fields would be in all directions, which means there will always be propagated fields that are properly aligned to efficiently transfer their energy to neural fibers.

An explosion that creates broadband EMPs presents a problem in the distance where measurement sensors are placed. The terms near field and far field refer whether a measurement is made within two wavelengths of the EM source, whereas far field is beyond two wavelengths. Typically, EM measurements of a radiation source are made in the far field, as the resulting EM radiation patterns in the far field are not the same as those produced in the near field. The victims of shell shock are within close proximity of the detonation point and the conventional definitions for near field and far field may not be applicable for that type of EMP source. Only very high frequency EMPs, with short wavelengths, are expected to be the cause of the neural fiber damage. A basic questions is, “What are the EM near field and far field distances for a specific spectrum range produced in an explosion?” This creates a difficult measurement environment for researchers as the EMP production in the exothermic reaction of munition detonations is not easy to measure close to the detonation point.

III. Electromagnetic Pulses of Munition Explosions

“The emission of electromagnetic radiation from a chemical explosion is well established.” That quote is from the LANL report, but it is not known to the general public and to many in other scientific disciplines. The LANL report was limited by the frequency capability of the measurement instruments available at that time. All the references cited in ref. (5) were before 1993 and there have been significant improvements in antennas and measurement instruments, which now includes readily available high-speed video recording equipment. Another interesting quote from the LANL report is, "A statistical analysis of an excess of 100 experiments at various distances from several different charge masses shows that the magnitude of the electric field is directly proportional to the explosive mass.” Some explosive materials with the same mass produce higher energy output than others, and I suspect that improved measurement instruments and techniques will be able to distinguish EM and other characteristic differences.

The EMP characteristics of munitions explosions are still being explored to identify how electronic equipment can be protected from them; this effort is done in parallel to protecting the equipment from the blast effects of explosions. A recent report on EMP emissions from explosions is in a 2010 IEEE publication on electromagnetic compatibility (EMC).[6] At this time only the abstract has been reviewed and that does not identify the specific frequencies and magnitudes of the associated EMPs.

Many contemporary studies of traumatic brain injury (TBI) caused by nearby munition explosions are centered around identifying the physical blast effects; the EM aspects of the explosions are not mentioned.[7] The alteration of brain characteristics by EM exposure is being studied, but most studies involve rather low levels of exposure,
typically that produced by cell phones. However, relatively low levels of electric current, that are induced by EM wavelengths that are well matched to the physical size of the neural fibers, can alter the permeability of mammalian brains.[8] High intensity EM fields with the same relative short wavelengths would be expected to do much more severe damage.

A magnetic field of an EMP moving through a conducting structure, metal or fluid, will induce an electric current in the structure. If the current produced exceeds the current capacity of the conducting structure, the structure will be damaged or severed. If the conducting circuit was a metallic wire with insulation, it overheats, melts or vaporizes a segment of the wire and its insulation, which creates a gap which terminates the conduction; adjoining insulation and wires can be damaged. If the conducting circuit is a fluid, such as cerebrospinal fluid, an over-current would cause heating that can convert the fluid into a gas bubble that expands and damages or ruptures the neural fiber connection. One might suspect that a severe over-current condition in a bundle of neural fibers could be the cause of a “honeycomb pattern of broken and swollen nerve fibres.” The honeycomb pattern would be related to a specific wavelength or multiple wavelengths of the EMP that did the damage, a harmonic frequency relationship.

IV. Recommendations

Military ballistic protection head gear should provide protection from the EMPs produced by nearby munition explosions.

The EM signatures, such as frequencies, amplitudes and pulse durations produced by various types of explosive material should be determined. Researchers should determine whether gamma and x-rays can be produced by the EM process of various sized munition explosions. Once the frequencies, pulse intensities and durations of munitions explosions are determined, the thickness of an EM cranial shield can be established.

Diagnostic procedures need to be improved to positively identify the presence of the hard brain damage of shell shock as compared to the soft damage of other types of trauma.

The susceptibilities of the nerve fibers in the frontal lobes of the brain to EMPs should be determined in comparison with nerve fibers in other parts of the brain and body.

V. References

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